REMARKS

Claims 1-8, 16-20, 22-26, and 28-38 will be pending upon entry of the present amendment. Claims 1, 16, 22, and 25 are being amended. Claims 9-15, 21 and 27 are being canceled. Claims 31-36 are new. No new matter is being entered.

The specification was objected to as failing to provide proper antecedent basis for original claims 6 and 16. The specification is being amended to include the elements of original claim 16 and thereby provide support for claims 6 and 16.

The applicants appreciate the indication that claims 7-8 and 21-22 are directed to allowable subject matter. Claim 16 is being amended to include the language of claim 21, which is being canceled. Accordingly, claim 16 and dependent claims 17-20 and 22-23 are in condition for allowance.

One embodiment of the present invention is a semiconductor device 90, such as a phase-change memory, that includes a first electrode 100 with a horizontal portion 102 having an end face 110 that contacts a chalcogenic active region 103 (See Figs. 4-5). The inventors discovered that by contacting the active region 103 with the end face 110 of the horizontal electrode portion 102, the contact area of the end face and active region could be made extremely small, and in fact could be sublithographic (e.g., 5-50 nm) in two dimensions (s, w) of the end face 110. Such an extremely small contact area enables the first electrode to heat the active region 103 using much less current in order to change the phase of the active region.

Claims 1-3, 6, 24-26, and 28-30 were rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 6,759,267 to Chen.

Chen does not disclose the invention recited in claim 1, as amended. Amended claim 1 recites an electronic semiconductor device that includes first conducting region having a longitudinal dimension delimited by an end face extending transversely to an upper surface of a semiconductor body and contacting a chalcogenic second conducting region at a contact area, the end face having width and height dimensions that are smaller than the longitudinal dimension.

Chen does not disclose such a device having a first conducting region with an end face that delimits a longitudinal dimension of the first conducting region, is transverse to the upper surface of a semiconductor body, contacts a second conducting region, and has width and

height dimensions smaller than the longitudinal dimension. Instead, Chen shows a polysilicon gate 40 with a silicide layer 44 that contacts a chalcogenic layer 46 along the entire length (the dimension into and out of the page of Figure 1) of a top of the silicide layer 44. The top of the silicide layer 44 is not transverse to the upper face of the body 12, is not an end face that limits a longitudinal dimension of the silicide layer, and does not have width/height dimensions smaller than the longitudinal dimension of the silicide layer.

It is difficult to determine whether the side (vertical dimension in Fig. 2c) of the silicide layer 44 also contacts the chalcogenic layer 46 instead of being blocked by the dielectric spacer 42, but even if it does contact the layer 46, the side of the silicide layer is not an end face that limits a longitudinal dimension of the silicide layer and does not have width/height dimensions smaller than the longitudinal dimension of the silicide layer. Chen does not explicitly state that the dimension of the silicide layer 44 into and out of the page is the length (i.e., the longest dimension), but one skilled in the art likely would assume that it is. For example, U.S. Patent Application Publication No. US 2004/0166604 to Ha et al. (cited in an IDS being filed herewith) shows a phase change memory similar to Chen (compare Fig. 3 of Chen to Fig. 1 of Ha et al.). Figure 4 of Ha et al. shows that the gates 57a, 57b of the transistors of the phase change memory cells have their longest dimension going into and out of the page of the cross-sectional view of Figure 5, which is like the cross-sectional views of Figs. 1-2C of Chen. Thus, Chen does not disclose, explicitly or inherently, that the vertical side wall of the silicide layer 44 delimits the longitudinal dimension of the silicide layer or has width/height dimensions smaller than the longitudinal dimension.

For the foregoing reasons, amended claim 1 is not anticipated by Chen. Claims 2-3, 6, and 24 depend on claim 1, and thus, are also not anticipated by Chen.

Claim 25 is being amended to include that language of claim 27, which as admitted by the Examiner, was not anticipated by Chen. Accordingly, claim 25 and dependent claims 26 and 28-30 are not anticipated by Chen.

Claims 1-3, 6, and 24-28 were rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent Application Publication No. US 2004/0245603 to Lowrey et al. ("US Lowery").

US Lowery also does not disclose the invention recited in claim 1, as amended. In particular, like Chen, US Lowery does not disclose a device having a first conducting region with an end face that delimits a longitudinal dimension of the first conducting region, is transverse to the upper surface of a semiconductor body, contacts a second conducting region, and has width and height dimensions smaller than the longitudinal dimension. Instead, US Lowery shows a device 100 with a phase change material layer 250, an insulative layer 260, and a conductive contact layer 270 having vertical side walls that contact the layer 250. The vertical side walls of the contact layer 270 are not an end face, do not delimit a longitudinal dimension of the layer 270, and do not have height/width dimensions smaller than the longitudinal dimension of the layer 270. Like Chen, US Lowery does not explicitly disclose that the longitudinal (i.e., the longest) dimension is into and out of the page of Fig. 1, but one of ordinary skill in the art would likely assume that it is, particularly in view of Ha et al. as discussed above. As such, the vertical side walls of the layer 270 would not have a width smaller than the longitudinal dimension of the layer 270. Accordingly, claim 1 and dependent claims 2-3, 6, and 24 are not anticipated by Lowery.

As mentioned above, claim 25 is being amended to include that language of claim 27. Although the Examiner included claim 27 in the listing of claims being rejected based on US Lowery (page 8 of Office Action), the Examiner admits that claim 27 was not anticipated by US Lowery on page 13 of the Office Action. Accordingly, claim 25 and dependent claims 26 and 28-30 are discussed in more detail below with respect to the obviousness rejection of claim 27.

Claim 5 was rejected under 35 U.S.C. § 103 as being obvious in view of Chen or US Lowery.

Claim 5 is nonobvious in view of Chen or US Lowery for at least two reasons. First, as discussed above, Chen and Lowery do not teach the features of claim 1, from which claim 5 depends. In addition, there is no suggestion to modify Chen or US Lowery to achieve the features of claim 1. Both Chen and US Lowery appear to be attempt to maximize the contact area between the conductive contacts and the phase change material, and thus, one would not be motivated to contact the phase change material with an end face having width/height dimensions small than the longest dimension of the conductive contact.

Second, the features recited in claim 5 are nonobvious in view of either Chen or US Lowery. Claim 5 recites that the height and width of the end face of the first conducting region are both comprised between 5 and 50 nm. Such a dimension range is not a mere "routine optimization" because the range of 5 to 50 nm is a sub-lithographic range. Neither Chen nor US Lowery nor the general knowledge in the art suggests how one skilled in the art could make a conducting region with two sub-lithographic dimensions. As the work "sub-lithographic" suggests, such sub-lithographic dimensions cannot be formed using a photolithographic mask to define such small features, so it would not have been within the ordinary skill in the art to make such a conducting region with two sub-lithographic dimensions.

It is possible that one of the dimensions of the side walls of Chen's silicide layer 44 or US Lowery's contact layer 270 could be sub-lithographic because it is known in the art how to make a thin layer (e.g., Chen indicates that the thickness of the layer 28 is 20-200 nm), but nothing in Chen, US Lowery, or the general knowledge of the art suggest how two dimensions could be between 5 to 50 nm. In contrast, the inventors employed a quite sophisticated method of using a dielectric spacer 28a to form a conductive contact 27a with two sub-lithographic dimension from a thin conductive film 27 (see Figs. 8-12 of the application).

For the foregoing reasons, claim 5 is nonobvious in view of Chen and US Lowery.

Claims 4-5 and 27 were rejected under 35 U.S.C. § 103 as being unpatentable over Chen or US Lowery in view of PCT publication WO 0209206 to Lowery et al. ("PCT Lowery").

The cited prior art does not teach or suggest the invention recited in claims 4-5. As discussed above, Chen and US Lowery do not teach or suggest the features of claim 1, from which claims 4-5 depend. In addition, PCT Lowery does not teach or suggest the features of claim 1 that are missing from Chen and US Lowery. PCT Lowery shows conductive spacers 130'a,b having end faces that are rectangular in Fig. 9D, but PCT Lowery does not suggest that the end faces delimiting the longitudinal dimension (in direction Y and of length w1) contact the phase change layer 290. Alternatively, the top faces 132, 137 appear to be designed to contact

the phase change layer 290, but those faces are not transverse to the longitudinal dimension and the upper surface of the semiconductor body 102.

With respect to claim 5, the cited prior art does not teach or suggest the dimension ranges of the end face. As discussed above, Chen and US Lowery do not teach or suggest the dimensional ranges and it would not have been a "routine optimization" to modify Chen and US Lowery to employ the dimensional ranges because the ranges are sub-lithographic. Like Chen and US Lowery, PCT Lowery does not teach or suggest a way to make a conductive region with an end face having two sub-lithographic dimensions, such as the 5 to 50 nm range recited in claim 5.

Accordingly, claims 4-5 are nonobvious in view of the cited prior art.

The cited prior art does not teach or suggest the invention recited in claim 25 as amended. Amended claim 25 recites that "the first conducting region having a contact surface that contacts the second conducting region and extends transversely to the upper surface, wherein the contact surface has a generally rectangular shape having a height and a width, wherein the height is comprised between 5 nm and 50 nm and the width is comprised between 5 nm and 50 nm." As discussed above with respect to claim 5, the cited prior art does not teach or suggest a desire or a way to create a conducting region with a contact surface having two sub-lithographic dimensions, such as the 5 to 50 nm dimensional ranges recited in claim 25. Accordingly, claim 25 and dependent claims 2 and 28-30 are nonobvious in view of the cited prior art.

New claims 31-37 recite a device that includes a first conducting region having "a longitudinal direction delimited by an end face extending transversely to the upper surface and contacting a side wall of the second conducting region, the end face having a width smaller than a corresponding width of the side wall of the second conducting region and a height smaller than a corresponding height of the side wall of the second conducting region."

The cited prior art does not teach or suggest such a conducting region with an end face having height/width dimensions smaller than the corresponding height/width dimensions of a chalcogenic second conducting region. Instead, Chen appears to contact the silicide layer 44 along the entire length of the chalcogenic layer 46 into and out of the page of Fig. 1. Similar considerations apply to both US Lowery and PCT Lowery. None of the references suggests a

desire to contact a reduced portion of a side wall of a phase change layer with a conducting region end face having smaller dimensions than the side wall of the phase change layer. Similar to the discussion above, the cited references all appear to show a conductive contact with one reduced dimension, but none of them show a way to reduce both of the height/width dimensions of an end face to provide a much smaller contact area between the conductive contact and the phase change layer.

For the foregoing reasons, new claims 31-37 are in condition for allowance.

New claim 38 depends on claim 1, and thus, novel and nonobvious for the reasons expressed above. In addition, claim 38 further recites that the first conducting region contacts the second conduction region only with the end face of the first conducting region. The cited prior art do not teach or suggest such a feature. Instead, Chen contacts the top face of the silicide layer 44 with the bottom face of the phase change layer 46. Both US Lowery and PCT Lowery contact their phase change layers along its entire length rather than only with an end face. Accordingly, claim 38 is in condition for allowance.

The Director is authorized to charge any additional fees due by way of this Amendment, or credit any overpayment, to our Deposit Account No. 19-1090.

All of the claims remaining in the application are now clearly allowable. Favorable consideration and a Notice of Allowance are earnestly solicited.

Respectfully submitted,

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